

Stem Cell Research: The Facts and the Debate

“No experiment should be conducted where there is an *a priori* reason to believe that death...will occur” (Życiński 522). This quotation from the Nuremburg Code highlights the primary focus on stem cell research, as seen through the public eye. Much of the attention given to stem cells revolves around the political and ethical controversy surrounding them, and there is very little focus on the science that explains this amazing new medical technology. However, a thorough understanding of the science and facts behind stem cell research can help to determine answers to the ethical and accompanying political questions regarding stem cells and their use. A further complication to the average citizen’s understanding of the controversy is the distortion that occurs when a scientific discovery is reported on via a regular, non-scientific, news agency. For instance, many astounding breakthroughs with “stem cells” have been reported, several of these having been done with animals, in particular mice, although the article about the breakthrough does not specify that the research was done with animal stem cells, using the phrase “stem cells” alone, leading readers to believe that medical uses of the research lie only months away. Another source of misunderstanding is the difference between embryonic and adult stem cells. Much of the political debate concerns the use of embryonic stem cells, and the difference between these and adult stem cells, the use of which is not very highly contested, is not widely understood. Although other types of stem cells exist, much of the debate is between adult and embryonic stem cells, and the accompanying biology, obtainment procedures, politics, and ethics thereof.

Central to the understanding of stem cells and the research of such cells is the comprehension of what a stem cell actually is. One stem cell researcher, Christopher Scott, defines a stem cell as a “cell that has the capability to both self-renew ... and differentiate into

mature, specialized, cells” (222). This definition describes a broad set of cells, ranging from those in the amniotic fluid surrounding an embryo that is in the uterus (Trounson 68) to those that exist in a fully developed human being. The two primary types of stem cells, though, are embryonic and adult stem cells, and, in the main, these two types of cells can be discussed using the same terms and knowledge that describe any stem cell. The primary factor that determines both a stem cell’s identity as a stem cell and its utility as a research tool is potency. Stem cells can be totipotent, pluripotent, or multipotent. If a cell is totipotent, it can differentiate into any type of cell in the whole body, an example being the fertilized egg, which can be described as “the ultimate stem cell” (Panno 5). Pluripotent cells are able to form many types of cells, from any of the three germ layers (different divisions of body tissues) that are formed during embryonic development. Multipotency refers to a capability to create a few types of cells, according to the germ layer from which the stem cell originated, such as a hematopoietic stem cell, which has only been observed to form blood cells (Bongso and Richards 831). Plasticity is also important in the description of stem cells, being “the ability to transdifferentiate or dedifferentiate” (Scott 64), where dedifferentiation is regression to a younger, more potent, form of a cell, and transdifferentiation is to form a cell from a germ layer other than the stem cell’s (Scott 215,223). Another interesting feature of stem cells is that, while the fertilized egg is generally considered totipotent, according to researchers Bongso and Richards, by “strict definition,” it cannot be because it does not self-renew (Bongso and Richards 829). This demonstrates the flexibility in the definition of stem cells, because stem cell research is still a relatively young science. Scientists’ knowledge of how an embryo develops has also helped to develop an explanation of stem cells, by discovering their origins.

The developmental stages in the early life of a human embryo are both the time when

stem cells first appear and the source of the greatest political and ethical debate, that is, deciding at what point an embryo becomes fully human and thus entitled to the full protection of the law. The development of a child begins with the fertilization of an oocyte, or egg cell, forming an embryo. A few days after fertilization, the cells of the embryo have formed a spherical mass called a blastocyst. The blastocyst is composed of two major parts: the inner cell mass, from which embryonic stem cells are derived, and the trophoblast (*See Figure 1*) (Panno 3-4). After six days, the embryo needs to implant in the wall of the uterus, and the cells of the trophoblast will contribute to the placenta, umbilical cord and other connections with the mother's blood supply, including the amniotic fluid surrounding the baby (Scott 28). The cells of the inner cell mass differentiate into three germ layers: the ectoderm, the mesoderm, and the endoderm. These cells become progressively more specialized as they begin to form different types of cells, depending on the germ layer from which they originated. The cells from the ectoderm will eventually cover the whole embryo, forming neurons, skin, eyes, and ears, while the cells from the mesoderm form inner support structures such as the skeletal, muscular, and circulatory systems. Likewise, the cells from the endoderm become the digestive and respiratory systems (Panno 4). These cells will continue to differentiate, forming organs and organ systems at such a rate that after two months of development, the embryo's limbs, heart, brain, and facial features will be easily recognizable (Scott 31). The versatility that is demonstrated by the cells of the inner cell mass is what makes them so amazing, and it is what gives them their great potential for research and possible cures. Scientists' understanding of the developmental process of the human embryo has helped them to learn where to find and how to obtain human embryonic stem cells.

Obtaining and culturing embryonic stem cells for research use posed a large problem until recently. The first person to do so successfully was Dr. James Thomson, who obtained the

cells from the inner cell mass of embryos donated from an *in vitro* fertilization clinic. After growing the embryos into blastocysts, the trophoblast was removed, killing the embryo, and the inner cell mass was then revealed, enabling access to the embryonic stem cells within (Scott 2, 52). His method is the primary process that is currently used in the majority of research facilities, because the legal and ethical debates about most other procedures are more intense than the dispute of his system. After a scientist isolates the stem cells, they are grown on a feeder layer composed of molecules that provide nutrients for growth and prevent differentiation of the stem cells. These feeder layers can be composed of materials from animals or from humans, but humans are the preferable source because stem cells cultured on feeder layers from animals are more likely to provoke an immune response, limiting their potential therapeutic use (Scott 52-53). Another procedure that is used to obtain embryonic stem cells is the same method that was used by Scottish scientist Ian Wilmut to clone Dolly, the first cloned sheep. Somatic cell nuclear transfer is used to produce a cloned egg from which embryonic stem cells can be derived. In order to do so, an egg cell's nucleus is removed, and it is fused with a somatic (adult) cell, producing a genetic clone of the animal from which the somatic cell was derived. This process is known as therapeutic cloning, in which embryos are produced for the express purpose of making use of them for research, as opposed to reproductive cloning, the cloning of humans in order to raise them to live a full life, which is almost universally banned (Scott 46, 53-54, 221). Somatic cell nuclear transfer can also be used with the egg cell of an animal, combined with the genetic information of a human, in order to produce an embryo for research purposes. This is discussed as a possible alternative to therapeutic cloning (Greely 0573). Although most scientists prefer the use of embryonic stem cells for research, their obtainment is made difficult by legal and ethical barriers. The use of adult stem cells will definitely remain legal and ethical, although

they are more difficult to find and obtain.

Adult stem cells are found scattered all over the body. They are very diverse and have great potential, but their similarity to other, non-stem cells makes them difficult to identify when mixed among the many other types of cells in the body. The identification of adult stem cells rests on more circumstantial evidence than does that of embryonic stem cells, and finding them depends primarily on their known characteristics. The primary characteristics that can be utilized in the recognition of adult stem cells are potency and asymmetric division. In order to classify any type of cell as a stem cell, they must be potent to some extent, and to be useful, pluripotency is preferred (Scott 59-64). Two primary methods for determining if a cell is pluripotent are (1) to transplant a cell into an adult organism, often a mouse that has been genetically engineered to be without an immune system, and to see if the cell divides to form a teratoma (a benign tumor) that is composed of cells from all three germ layers, or (2) to mark and transplant the cell into an embryo and to see if the cell contributes to the formation of all parts of the embryo (Scott 73). Another way to identify an adult stem cell is to observe cells that divide asymmetrically. Stem cells divide asymmetrically, that is, when they divide, one daughter cell remains a stem cell, and the other begins to differentiate into other types of cells. This method is relatively slow; however, so in order to quickly repair damaged tissue, progenitor cells are formed. These cells divide rapidly, by mitosis, and form two differentiated and usable daughter cells, and their presence usually indicates the presence of an adult stem cell. Another challenge in the use of adult stem cells is the understanding of the niche, the physical location of stem cells in the body. The niche controls and protects the stem cells, and understanding its function is vital to the obtainment of adult stem cells (Scott 64-70). A primary difference between adult stem cells and embryonic stem cells is that adult stem cells are ethically and politically accepted, whereas as the

use of embryonic stem cells is under much debate.

The political aspect of the stem cell research debate is a very hotly contested area. Many different groups of people, as well as individuals, have differing views on the acceptable uses of stem cells, and these views are expressed to elected politicians, who promote laws that support these outlooks. Consequently, the United States has not yet reached a final, yes-or-no, answer to the question of whether to use human embryonic stem cells in research facilities, although the use of adult stem cells is generally accepted as both legal and ethical. Traditionally, political control over research is achieved through the regulation of funding. The federal government can give grants to scientists that wish to perform research, and Congress and the president can decide if a certain type of research will or will not be funded, limiting advances in any field of research that is banned. The debate in the United States started with Dr. Thomson's successful isolation of a human embryonic stem cell line. This caused many organizations to raise a loud protest to Congress, which responded by passing, in 1974, an act that banned embryo research, and that act has lasted more than thirty years to this date (Scott 151-153). The actions of three successive presidents serve to demonstrate the extent of the controversy. During the term of President George H.W. Bush, Congress voted to lift the ban, but he vetoed the decision, and the veto was not overridden. However, when President Bush left office, President William Clinton issued an executive order to reverse the country's stance and order federal funding for human embryonic stem cell research. This prompted a flood of pro-life letters directed to President Clinton, who removed his backing from the order, and it never carried through for fear of a Congressional reaction. Finally, President George W. Bush, on April 9, 2001, determined that federal funding could only be used on research on stem cell lines that were created before his 9:00 PM announcement (Scott 155). As of now, this decision has stood, but there is still much debate

surrounding the issue. It remains to be seen how long this decision will remain in effect, and there have already been repercussions from the political indecision of the United States government.

One of the primary consequences of the limitations on the use of human embryonic stem cells in the United States has been the falling-behind of American researchers in that field of research. The United States no longer plays a prominent role in world research, one example being the fact that it was a Swedish scientist, Anders Bjorklund, who was the first to make a therapeutic use of cells to treat brain disease (Scott 152-153). This slowdown of American research is due primarily to the fact that the only stem cell lines that can be investigated using federal funds are grown on mouse feeder lines, rendering them virtually useless for medical therapies (Scott 164-165). President George W. Bush's decisions regarding his President's Council on Bioethics have also had repercussions. This board advises the president, and claims that appointments are weighted in favor of those who support President Bush's policies have lessened respect for the Council's publications and advice (Scott 161-162). Also threatening American research is a loss of trained researchers. Alden Mayer, the director of the Union of Concerned Scientist, has stated, "there will be an exodus of scientific talent from the federal government" (Scott 162), and this departure of already trained scientists is augmented by the fact that newly emerging scientists are not choosing to specialize in human embryonic stem cell research, which deprives the research of an essential backbone, introducing the possibility that research could not resume at a full pace even if the political environment changed (Scott 176). Another result of the political atmosphere is that private institutions have taken steps to provide funding on their own, negating the effects of the federal government's decisions. A striking example of this is the case of the state of California. In response to President Bush's restrictions

on human embryonic stem cell research, Proposition 71 was introduced and passed, creating the California Institute for Regenerative Medicine. This organization plans to provide funding for human embryonic stem cell research on a scale of three billion dollars, “with emphasis on types of research not fully supported by the ... federal government” (Greely 0571). Supporters of human embryonic stem cell research have been severely affected by these consequences, and offer ethical reasons to promote the use of human embryonic stem cells.

As science’s power to alter lives increases, its influence on society also increases, creating moral issues relating to many new fields of technological advancement. The focus of many scientists on ideas that devalue human life has led to many of the problems that are now present concerning stem cell research. Peter Singer, a controversial radical thinker, expresses this concept with the question: “Why does the fact that something is human life mean that it is something precious that we should protect?” (Singer 38). This view has influenced the thinking of a large proportion of those who argue in favor of using human embryonic stem cells for research, although many other reasons are also used. A common justification for the destruction of embryos uses the concept of the “greatest good,” suggesting that the destruction of an embryo is permissible because of the possibility for medical treatments for ailing post-birth humans. This claim is enhanced by the emotional feelings that people feel towards suffering relatives as opposed to an embryo. Watching or experiencing the suffering of a disease causes many to vigorously campaign in favor of stem cell research in hopes of procuring a treatment, a notable example of this being Christopher Reeves. Others have reasons that can claim to be rooted in science: James Wilson of the University of California, Los Angeles, deems that human status is granted by other members of the human family, and that this status is conferred more readily as the embryo’s appearance becomes increasingly similar to that of other humans, and Michael

Gazzaniga of the President's Council on Bioethics, states that human rights should be granted an embryo after passing the six-month mark, when survival outside of the womb can be accomplished (Scott 134-135). Two Lutheran theologians, Peters and Bennett, use all of this uncertainty surrounding the status of an embryo to state that it should be used as a source of stem cells, precisely because it is unknown whether it is a human (Scott 131-132). All of these arguments, however, are met or superseded by those that contend for the defense of the dignity of human life.

As a definition of pro-life beliefs, the Catholic Church very clearly states, "Since it must be treated from conception as a person, the embryo must be defended ... like any other human being" (Catechism 548), emphasizing the individual value of each human life, regardless of age. This concept of affirming basic human rights also counteracts the "greatest good" argument: the Nuremburg Code, as a response to the horrific use of human beings in Nazi experiments, also a demonstration of the "greatest good" argument, clearly states that no experiment should end in the death of a human patient (Życiński 522), and this is one of several secular reasons to protect the life of an embryo. A purely biological definition rests on the fact that each individual is made so by his DNA: thus, an embryo, with its DNA, is a unique human person, and worthy of the same respect that is accorded to other humans. In response to queries about an embryo's moral status, Życiński points out that it is not necessarily implied that the embryo has the moral status of a human person, with all of the associated responsibilities; however, claims about personhood are not necessary in order to understand a moral obligation to protect what is human life, even from a scientific perspective (520). There is also an emotional pull here: each human being was once an embryo, and all people have shared that common experience, allowing one to empathize with the developing child (Życiński 520). Another idea that should be considered is that the

killing of embryos for research only has the potential of *prolonging* a life at the cost of another, something that is obviously wrong and compares to the Nazis' use of human subjects. Although these pro-life beliefs are very strong, there are still many outside doubts as to the status of an embryo, but this uncertainty leads pro-life believers in the other direction: because the embryo's human status is not widely accepted, it should not be used as a source of stem cells because it may be (and is) human. However, another source of stem cells exists, one that may provide a compromise between pro-life and pro-stem cell groups.

Each side of the stem cell debate has its own reasons for desiring to allow or permit the use of human embryonic stem cells for research. Scientists contend that the use of human embryonic stem cells is essential because adult stem cells are not potent enough to allow them to be useful as research tools or to provide cures. They also cite the difficulty in obtaining adult stem cells, saying that they cannot be obtained efficiently enough to allow their therapeutic use. These people insist that the use of human embryonic stem cells must be allowed to ensure a better life for future generations of the human race. On the other hand, individuals who defend the rights of unborn children confirm that it is wrong to kill an embryo, and maintain that the use of human embryonic stem cells is morally wrong. These people realize that much of scientists' funding is provided by the tax dollars of American citizens and that if any group of tax-paying, and therefore research-funding, individuals expresses their desire to limit scientists' use of money, they should be heard and respected. There is, however, another source of stem cells. In January of 2007, Anthony Atala and his colleagues published their findings that the amniotic fluid contains pluripotent stem cells. This fluid surrounds that child as he/she develops in the uterus, and contains cells derived from the embryo. These cells are routinely removed during amniocentesis, a process during which a small amount of this fluid is removed for genetic

testing. Atala used excess fluid obtained from backup fluid that was used for these tests, and discovered that it was a source of pluripotent stem cells (Trounson 68). These cells could be an excellent compromise between the two moral positions because they are pluripotent, giving them a high utility for research and therapeutic purposes, and because they are regularly obtained in a manner that does not harm the fetus. This source of stem cells is morally acceptable for scientific purposes, and should satisfy most scientists' demands for usable stem cells to perform research on, allowing science and medicine to advance and provide long-awaited benefits without ignoring important ethical considerations.

Many differences are evident between adult stem cells and embryonic stem cells, a primary difference being the level of controversy of their source. While adult stem cells are derived in an uncontroversial manner from an adult human being, embryonic stem cells are derived from a human embryo, a process that results in the loss of the life. This loss of life is the focal point of the debate surrounding stem cell research. Different organizations that represent the public express their beliefs, and these views affect the decisions of politicians, especially in the United States, where much debate still exists over the use of embryonic stem cells. Under President Bush's administration, moves have been made to limit the destruction of embryos, but no final decision has been reached, and it is the beliefs of citizens and of their elected representatives that will decide the final fate of the embryo in America. These opinions must be informed opinions: an opinion that has not been properly informed endangers the integrity of the lawmaking system, causing citizens to cast their votes based on something other than the science that explains the target of the debate. Also, this research into the facts behind the debate must be made with an open mind and from many perspectives. The view of the majority of scientists, for example, would be largely biased toward the use of embryonic stem cells in research, whereas

other beliefs, such as those of the Roman Catholic believer, confirm the dignity of all life and the necessity of its protection. An honest study of all perspectives must occur in order to find the truth. The scientific differences among all types of stem cell research must be clearly understood in order to properly grasp the essence of many published findings, and to see and move past any inaccuracies contained within secondhand reports of these discoveries. “Science and technology by their very nature require unconditional respect for fundamental moral criteria” (Catechism 552), and, while the use of embryonic stem cells in research remains controversial, it is the accurately informed beliefs of the American citizen that will ultimately affirm the value of every human life.

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